AUDIO—HIGH FIDELITY

HIGH-GAIN TRANSISTOR AUDIO AMPLIFIER

By JOSEPH BRAUNBECK

Using six transistors, unit solves impedance mismatch problems

TRANSISTORIZED audio amplifiers having low and medium gain and using one to four junction transistors are common. But how many transistor stages may be added without risking instability and excessive noise? This amplifier shows that up to six stages may be combined without these troubles.

Excellent results are obtained using grounded-collector and grounded-emitter stages together. Such a high-gain transistorized amplifier has many applications. Besides all purposes for which you need an audio amplifier with high gain and low output, it may be converted to an acoustic burglar alarm, a receiver for low-frequency wireless communication, a "speech-on-light" receiver, etc.

A junction transistor may be connected three ways: you can ground either base, emitter or collector. The grounded-base circuit, which is most important for the point-contact transistor, is not very common in junction-transistor circuitry. Grounded-emitter stages have to be matched to a low-impedance input and a high-impedance output. A grounded-collector stage, however, has much different matching impedances: its input impedance is high, output impedance low.

If, as usual, several grounded-emitter stages are combined by transformerless R-C coupling, there is considerable mismatch between any two succeeding stages (Fig. 1-a), reducing gain. This may be avoided by combining grounded-emitter and grounded-collector stages (Fig. 1-b), providing better interstage matching. It is still not quite correct from the theoretical point of view, but the horrible mismatch between two grounded-emitter stages is avoided.

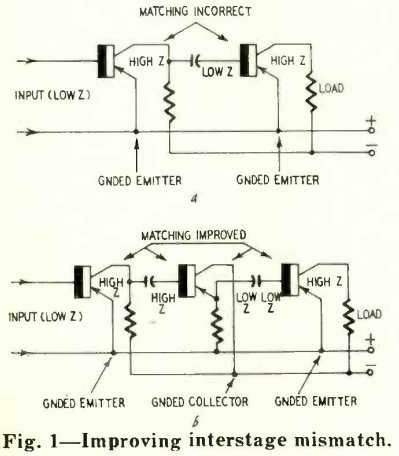


Fig. 1—Improving interstage mismatch.

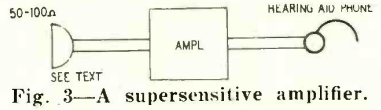


Fig. 3—A supersensitive amplifier.

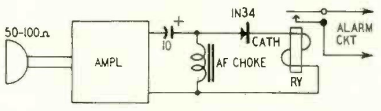


Fig. 4—An acoustic burglar alarm.

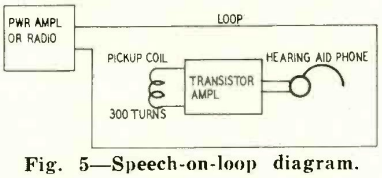


Fig. 5—Speech-on-loop diagram.

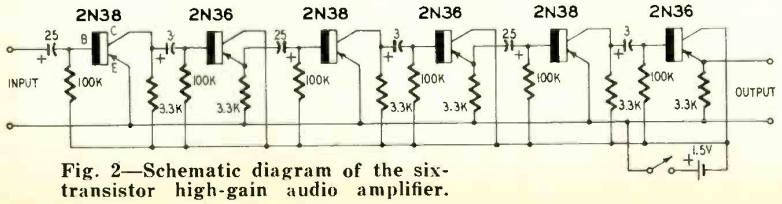


Fig. 2—Schematic diagram of the six-transistor high-gain audio amplifier.

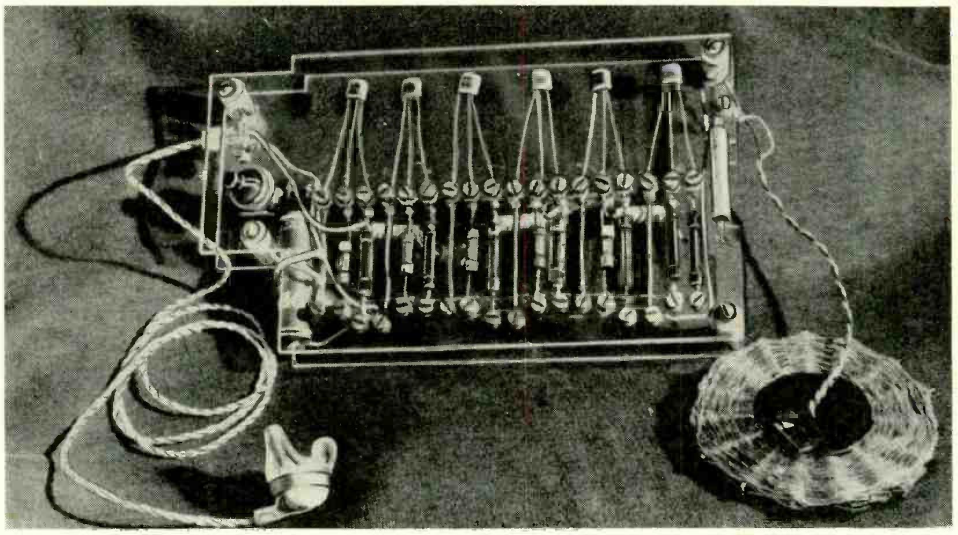
The complete amplifier circuit is shown in Fig. 2. The grounded-emitter stages use 2N38 junction transistors, the 2N36's are used with their collectors grounded. The 100,000-ohm resistors between the transistor bases and negative supply provide the necessary bias. The internal resistance of the single flashlight cell (which is the whole power supply) is low enough to prevent motorboating.

Every grounded-collector stage is thermally stabilized by itself, thanks to the load resistor in the emitter lead. All load resistors are 3,300 ohms. Coupling capacitors are 3 μf for the grounded-collector inputs and 25 μf for the grounded-emitter inputs. These values are not at all critical. The output is designed for use with a low-impedance miniature earphone. A 3,300-ohm load resistor shunts the output terminals to permit an oscilloscope or similar test gear to be connected to the amplifier.

The input is designed for low-impedance matching, too. A dynamic or magnetic microphone may be connected directly to it.

Circuit applications

What is this elaborate amplifier good for? One possible application is shown in Fig. 3. Take a single headphone with an impedance of between 50 and 100 ohms. Connect it as a magnetic microphone to the input of the amplifier. Listen with a hearing-aid type miniature earphone—you will hear a faint hiss. This is the noise which prevents you from adding further stages. The amplifier now serves as a supersensitive listening device, but it is not a hearing aid! *For this purpose amplification is too great.* But you can use it to hear many things which you never heard before. For example, put the microphone on your chest and listen to your heartbeat. Do not speak while you do so; it would be painful for your ears.



The high-gain amplifier connected to pickup coil for speech on loop.

Acoustic burglar alarm Disconnect the listening earphone from the amplifier. Add a coupling capacitor, an af choke, a crystal diode and a sensitive relay (Fig. 4). This changes the listening amplifier into an electronic burglar alarm. Any noise picked up by the microphone generates a voltage across the output terminals of the amplifier. This is rectified by the crystal diode, and rectified current actuates a sensitive relay.

For best results use a highly sensitive relay like the Weston Sensitrol or the Siemens polarized relay. They hold the contacts closed after their coil has been energized. Thus, noise starts the alarm which remains on until it is reset. Polarized telegraph relays are much quicker acting than the moving-coil types.

This alarm is very sensitive. It responds to speech at a distance of 30 feet. Nobody can break through a door fitted with the microphone. The relay will snap on if you rub the door with your fingertip.

Speech on loop Wireless communication within a certain area—a garden, house or room—is often established with a "speech-on-loop" system. A loop of wire surrounds the area. The loop is connected to the low-impedance output of a power amplifier (Fig. 5). The receiver consists of a small pickup coil connected to an earphone via the amplifier. The receiver picks up messages or music transmitted by the big loop everywhere inside as well as for some distance outside of it.

If you use the six-stage transistor amplifier instead of a conventional hearing-aid circuit, real "dx" may be obtained. I installed one loop around a small room in the second floor of an apartment house and fed into it the output of a small phono amplifier (about 4 watts). Reception was perfectly clear and loud all over the street in front of the house. A coil of 300 turns on a 2-inch-diameter form served as a pickup coil.

Phototransistor amplifier The first transistor may be replaced by a phototransistor such as the X-25 (made by Transistor Products, Inc.). Fig. 6 shows the modified circuit. This transistor needs no bias. It has to be connected "upside down" with the emitter negative and the collector positive, as it is an n-p-n transistor. This circuit is that of a sensitive modulated light receiver.

Circuits for obtaining modulated light have been described very often.

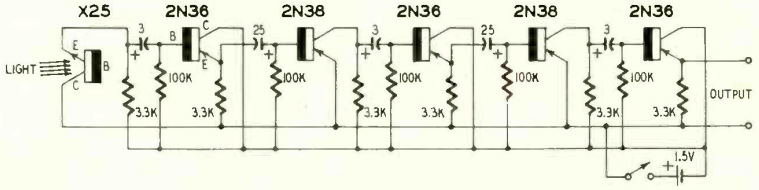


Fig. 6—A phototransistor amplifier. The X-25 does not require any bias.

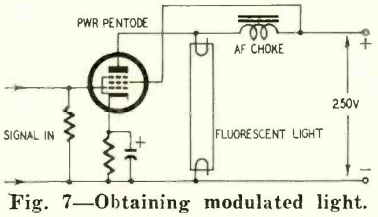


Fig. 7—Obtaining modulated light.

A very good one is shown in Fig. 7. A fluorescent light is connected in parallel with a power pentode. B plus is fed to both the pentode and the light through an audio-frequency choke. The control grid of the pentode is fed with the audio to be transmitted. Old hams will recognize this good old Heising modulator circuit. Though it works well indoors, you will have trouble when you want to focus the light beam over greater distances. In that case a conventional light modulator must be used.

As phototransistors are very sensitive to infra-red radiation, this device may also be used to detect infra-red radiation from devices such as hot stoves and soldering irons. In that case the radiation has to be chopped mechanically to give an ac signal. Chopping can be done with a small cardboard fan rotating in front of the transistor.

Construction

Thanks to the low input impedances of transistor stages as compared to vacuum-tube stages, capacitive hum cannot occur in a transistor amplifier. Therefore there is no need for a metallic chassis. The experimental model of the amplifier has been built on a sheet of polystyrene. Every soldering connection is supported by a soldering tag held by a screw. To keep the transistors from vibrating they are held in place by cellulose tape. Another polystyrene sheet of the same size and form is used as a cover to protect the transistor from curious fingers when the unit is used for demonstration. This way of construction might be called a sandwich layout, as the whole circuitry is enclosed between the polystyrene sheets. However, every point in the circuit is electrically accessible, as every soldering tag is held by one of the screws visible in the photograph of the amplifier. This unit is stable and should find many applications. END

Parts for transistor audio amplifier

6—3,300-ohm ½-watt resistors; 6—100,000-ohm ½-watt resistors; 3—3-μf, 3—25-μf, 6-volt filter capacitors; 3—2N36, 3—2N38 transistors; 1—1.5-volt cell; 1—spst switch; 1—chassis (could be constructed on a plastic subchassis); 2—sets of terminals (input and output).

for PEACE OF MIND BUY SAVINGS BONDS

PLEASE ADDRESS REPLY TO
"COMMANDING OFFICER
AND DIRECTOR"
AND REFER TO FILE NUMBER

U. S. NAVY ELECTRONICS LABORATORY
SAN DIEGO 52, CALIFORNIA

21 May, 1956

MAY 25 1956

Mr. Joseph Braunbeck
% Radio-Electronics Magazine
154 W 14th Street
New York 11, New York

Dear Sir:

Your article on a "High Gain Transistor Audio Amplifier" interests me. However, I would like to know some things about it, such as gain, power sensitivity (P_o/E_i), input and out impedances, frequency response, and distortion response. Your article is a teaser - now how about some information!

Very truly yours,

FRED A. STEINER
Code 2160

This is not to be construed as a request for services or supplies, but merely information, and it must be understood that the government will in no way be obligated by receiving this information.